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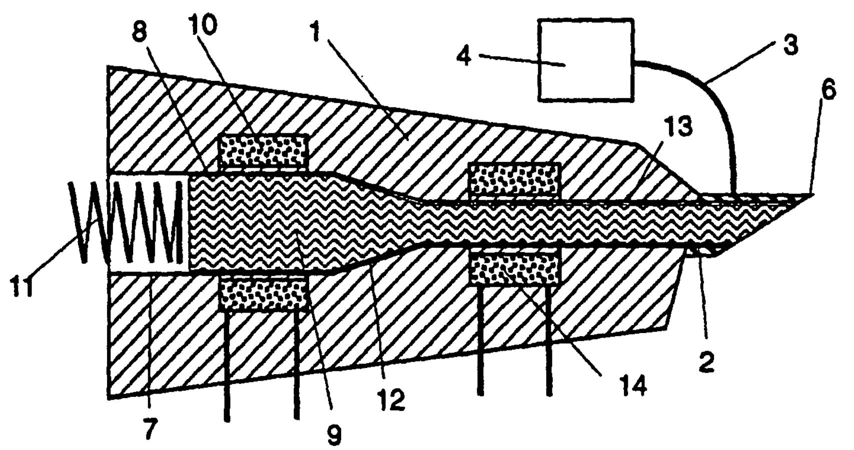

(57) Abstract

An apparatus and a method for the formation of droplets from meltable powdered solid or highly viscous materials such as inks (9) by reducing the viscosity (10, 14) of the material to a viscosity to enable droplet formation, providing the reduced viscosity ink to an ejection location (6), applying a constant or pulsed electrical potential (4) to the ejection location to form an electric field at the location and ejecting such droplets away from the ejection location by electrostatic means. Alternatively there may be constant electrical potential to form a constant electrostatic field at the ejection location and pulsed heating of the ejection location.

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METHOD AND APPARATUS FOR THE PRODUCTION OF DROPLETS

TECHNICAL FIELD

This invention relates to a method and apparatus for the production of droplets of material from a solid, powdered or highly viscous meltable material.

BACKGROUND ART

One particular application to which this invention may be applied is the transfer of droplets of high intensity colouring materials to a recording surface for the purpose of non-impact printing. It is to be understood, however, that the invention is not limited to delivering coloured materials for the purpose of non-impact printing but may be used to generate droplets of materials in general or to deposit other materials in a defined pattern on a substrate. Examples of other applications are the deposition of phosphors or fluoro phosphors for security coding, hot melt adhesives and propellantless aerosols. The invention may also be used for the propellantless production and ejection of particulate pharmaceuticals in a pharmaceutically acceptable meltable carrier.

This invention, however, will be discussed in relation to its application to printing but as indicated its scope is broader than this.

There are a number of different forms of equipment used for the non-impact printing systems which are generally referred to as ink jet printing. It is usual for ink to be fed through a nozzle, the exit diameter of which nozzle being a major factor in determining the droplet size and hence the size of the resulting dots on a recording surface. The droplets may be produced from the nozzle either continuously in which case the method is termed continuous printing or they may be produced individually as required in which case the method is termed drop-on-demand printing. In continuous printing an ink is delivered through the nozzle at high pressure and the pressure at the nozzle is perturbed at a substantially constant frequency which results in a stream of droplets of constant size. By applying charge to the droplets

and using an electric field external to the nozzle selected droplets may be deflected in their passage to the recording surface in response to a signal effecting the electric field whereby forming a pattern on the recording surface in response to the control signal. Drop-on-demand printing operates by producing local pressure pulses in the liquid in the vicinity of a small nozzle which results in a droplet of liquid being ejected from the nozzle at a selected time.

In either type of jet printing the colouring material is a soluble dye combined with binders to render the printed image more permanent in a liquid carrier.

The disadvantage of soluble dyes is that the printed image density is not high enough in many applications and that the dyes fade under exposure in the environment. A further disadvantage with soluble dye materials is that the quality of the printed image is dependent on the properties of the recording surface.

Pigmented inks are known to produce higher density images than soluble dyes and are also more permanent. Pigments may also be used in jet printers along with a carrier liquid but the production of a dense image requires a high concentration of pigment material in the carrier liquid. The high concentration of pigment material affects the droplet breakup in continuous printers and results in less uniform printing. Drop-on-demand printers do not have a high continuous pressure and the droplet generation is strongly dependent on local conditions in the nozzle, therefore the presence of pigments can modify the local nozzle conditions or block the nozzle such that droplets are not correctly ejected.

A further process, known as electrostatic ink jet printing, is characterised by an electrostatic pull on a liquid and is disclosed in for instance US Patent 3,060,429. This involves the generation and acceleration of charged droplets, from a nozzle containing the liquid, to a platen electrode by a high voltage being maintained between the nozzle and the platen. This process is further optimised by including a valving electrode that is used to interrupt or control the jet flow as well as two pairs of electrodes used to manipulate the flight path of the

droplets. Printing is achieved by locating a paper substrate just prior to the platen electrode and using a conductive solution of ink.

It has been proposed such as in US Patent No. 3,653,932 to use an ink which is solid at room temperature but to melt it in a heating tank before supplying it to a nozzle before subsequent drawing across a gap to a substrate by means of a high voltage. This system and apparatus has the disadvantage of unnecessary complexity of setting the voltage differences between the nozzle and a valving electrode and then between the valving electrode and a platen incorporating the substrate upon which printing is to be done. A similar arrangement is described in a published article in IS&T's Eighth International Congress on Advances in Non-Impact Printing Technologies (1992) pages 334 - 339.

It is an object of this invention to provide a method and apparatus for droplet formation from meltable powdered, solid or highly viscous materials such as inks in which the droplets are not produced by a nozzle and hence the size of the droplets are not affected by the size of the nozzle.

It is a further object of this invention to provide a method and apparatus for droplet formation from meltable powdered, solid or highly viscous materials such as inks with a high concentration of pigment or other solid materials so that high intensity images can be provided onto a recording surface or droplets with relatively large amounts of solid materials can be produced.

It is a further object of this invention to produce a method and apparatus for droplet formation from meltable powdered, solid or highly viscous materials such as inks including a carrier or using a carrier which is not necessarily conductive.

DISCLOSURE OF THE INVENTION

In one form therefore the invention is said to reside in a method of formation of droplets from a meltable powdered, solid or highly viscous material comprising the steps of reducing the viscosity of the material to a viscosity which will enable droplet formation, providing the

reduced viscosity material to an ejection location, applying an electrical potential to the ejection location to form an electric field at the location and thereby causing the reduced viscosity material to form droplets on the ejection location and ejecting such droplets away from the ejection location by electrostatic means.

The powdered, solid or highly viscous material may be an ink comprising a colourant and a carrier. The colourant may be a pigment.

The viscosity may be reduced by heating or by pressure.

It will be seen that by this invention the size of the droplets of the material such as an ink is not dependent upon the size of any nozzle which delivers the reduced viscosity material to the ejection location but is dependent upon the ejection location geometry, the level of the electrical field, the amount of heating at the ejection location and the nature of the reduced viscosity material such as an ink and its viscosity at the time of ejection.

It can also be seen that the present invention differs from the prior art in that the reduced viscosity material such as an ink does not necessarily include a conductive carrier liquid at the time of droplet formation. Droplets appear to be formed by electrostatic means acting upon the particles of solid such as a pigment within the reduced viscosity material such as an ink. The liquid portion acts solely as a carrier. The transfer of pigment instead of liquid solutions of colouring matter means that a more intense image can be formed on a substrate and a finer dot size can be formed with a quicker setting dot.

In one preferred form of the invention the electrical potential forming the field may be pulsed so that there is periodic formation and ejection of droplets from the ejection point.

The electrical potential will cause an electric field to build at the ejection location and may be dependent upon the geometry of the ejection location such as the radius of curvature of the ejection location and in a preferred embodiment of the invention the ejection location may be provided by a needle having a radius of curvature at its tip in the range of 5-50 microns. Alternatively the ejection location may be

provided by an elongate sharpened edge. There may be a number of ejection locations along the elongate edge or there may be a matrix of ejection locations.

The method of this invention may produce droplets of the material such as an ink in a size range of 1 micron to 500 microns in diameter or even larger depending upon the geometry of the ejection location, viscosity, type of carrier included in the material and voltage applied.

Preferably the carrier portion of the material is a non-electrically conducting liquid when in the reduced viscosity state and the solid material such as a pigment within the ink is comprised of chargeable particles. Preferably the chargeable particles may be charged to the same polarity as the voltage applied to the ejection location.

The electrical potential applied to the ejection location may be in the range of 500 to 6000 volts or higher.

In an alternative form the invention may be said to reside in an apparatus for generation of droplets of a material from a meltable powdered, solid or highly viscous material comprising means to reduce the viscosity of the powdered, solid or highly viscous material to a viscosity which will enable droplet formation, means to supply the reduced viscosity material to an ejection location, and means to apply an electrical potential to the ejection location to form an electrical field at the ejection location whereby to enable formation and ejection of droplets of the material from the ejection location.

Once again the powdered, solid or highly viscous material may be an ink comprising a colourant and a carrier the colourant may be a pigment.

The viscosity may be reduced by heating or by pressure.

It will be seen that by this form of the invention an apparatus is provided which will enable droplets of a meltable powdered, solid or highly viscous material to be produced and ejected from the ejection location.

The means to supply a flow of reduced viscosity material to the ejection location may be provided by various means depending upon the original nature of the material.

In the case of a solid meltable material there may be a spring loaded chamber containing pellets or a stick of the meltable material which at an end nearest the ejection location includes a heating means adapted to melt the meltable material to the required viscosity. Alternatively there may be two stage heating with the first stage adapted to soften the meltable material to such a viscosity that it can be forced under the spring pressure to a second stage heater which reduces the viscosity for the meltable material to the final required viscosity. With certain inks it has been found that if they are contained in a vertical closed vessel, two stage heating, aided by the force of gravity and/or the expansion of the material upon heating facilitates both viscosity reduction and feed to the ejection location.

Such heaters may be of the resistance type or so called induction type.

The resistance type of heater may be a resistance wire wound around a receptacle for the material.

The induction type consists of a coil wound about a ferrite core which is juxtaposed with respect to the vessel containing the ink. Alternatively the coil may be wound about the vessel wherein the said vessel acts as the core, directly heating the ink.

The ejection location may also be heated to maintain the required viscosity of the ink.

Such heating of the ejection location may be constant or pulsed. The heating of the ejection location may be a point source heater such as an infrared laser diode.

In the case of a powdered ink a powder feeder may be used to supply powder to the heating stage where it is melted in either one or two stages to a required viscosity for ejection.

In the case of a highly viscous ink this may be supplied in a cartridge with a spring loaded piston at one end. The spring pressure is adapted to push the paste-like or treacle-like ink directly to the heating chamber.

The ink may be composed of a low melting point wax or resin combined with a pigment phase. Examples of these materials include AC6, a polyethylene wax made by Allied Sinal; Elvax 210, an ethylene vinyl acetate resin made by Du Pont:; Syntha Wax, a hydrogenated castor oil made by Lever and Kitchen; Paraffin wax, made by Exxon and mixtures thereof. The pigment may be selected from any of a range of pigments depending upon the colour required. Examples of pigments include organic pigments such as Irgalite Blue LGLD, a Pigment Blue 15:3 made by Ciba Geigy: Microlith Black CT, a Pigment Black 7 made by Ciba-Geigy: Monolite Yellow GNA, a Pigment Yellow 1 made by ICI or inorganic pigments such as silicas, metallics or magnetic iron oxides.

Viscosity of inks may be optimised or pre-disposed for droplet formation. This may be achieved by controlling the temperature of the heating locations or specifically at the ejection location. Viscosity of the ink may be changed by the addition of a viscosity control agent such as Energol WM2, a paraffin oil made by BP Chemicals, or the like.

In one form the ejection location may be provided by a needle point having a radius of curvature of from 5 to 50 microns or the ejection location may be provided by an elongate edge having a semi-cylindrical surface having a radius of curvature of 5 to 50 microns. Alternatively the ejection location may comprise a matrix of ejection points.

The apparatus according to this invention may be adapted to provide droplets on demand or to provide a continuous stream of droplets which can be deflected by electrostatic means external to the apparatus. The supply of droplets on demand may be provided by providing a pulsed electrical potential or pulsed heating to the ejection location.

This periodically applied potential may be of any waveform which allows consistent ejection of droplets from the ejection location. Preferred waveforms include square waves and pulses which may have an offset or threshold potential.

Pulsed heating may be provided by a solid state infrared laser diode to provide a point source of heating at the ejection location.

Such a heating device may exhibit specific properties such as fast switching time, appropriate heat output with respect to wavelength, bandwidth and heating power for melting the material such as the material, and suitable spot size with respect to the dimensions of the ejection location.

Generally it can be seen that this invention provides droplet formation at an ejection location and the electrostatic ejection of such droplets.

Although the mechanism for operation of the droplet formation is not fully understood one theory, to which the applicants are not necessarily bound, is as follows: Particles in the reduced viscosity material flowing to the ejection location are inherently charged or charged to the same polarity as the ejection location. More and more particles continue to build up on the ejection location within a forming droplet of the carrier liquid of the material and with increasing repulsion the particles tend to move away from the ejection location until electrostatic repulsion between the ejection location and the forming droplet of the charged particles builds up to such an extent that surface tension of the entrained carrier liquid can no longer hold the droplet to the ejection location. At this stage the droplet is repulsed by electrostatic means.

It may be particularly noted that because the repulsion is substantially electrostatic no earthed substrate is necessary to attract the droplets to a substrate and in fact considerable distances of droplet flight can occur before they impinge a substrate. This enables suitable electrostatic or other forms of deflection equipment to provide whatever patterning of droplets is required on a substrate.

The arrangement may include a pair of ejection locations each producing droplets of one component of a two component adhesive system. This would provide an adhesive application gun.

This then generally describes the invention but to assist in understanding the invention reference will now be made to the accompanying drawings which show a preferred embodiment of the invention and illustrates a theoretical action of the invention.

BRIEF DESCRIPTION OF DRAWINGS

In the drawings:

FIG. 1 shows a sectional view of droplet formation apparatus of an embodiment of the invention;

FIG. 2 shows a sectional view of an alternative embodiment of a droplet formation apparatus; and

FIG. 3 shows a sectional view of a further alternative embodiment of a droplet formation apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 illustrates the one embodiment of the invention for use in forming droplets of an ink.

The apparatus for generation of discrete droplets from a solid ink consists of a body 1 which may be of an insulating material fashioned to a tapered point. Extending from the body is a hollow tube 2 of an electrical and thermal conducting material which is electrically charged by electrical conductor 3 extending from a power source 4. The ejection point 6 is formed at a tip of the tube 2 and is of a selected radius of curvature, in this case a spherical point. The body has an aperture 7 extending through it to the tube 2. The aperture 7 is comprised of a first portion 8 of a first diameter, adapted to receive a stick 9 of a solid ink. A heating coil 10 around the first portion 8 provides heating to soften the stick of ink 9 to such an extent that spring 11 can extrude the ink through a tapered portion 12 of the

aperture 7 into a second portion 13 of reduced diameter. In this second portion 13 a further heating coil 14 provides heating to further melt the ink until it is at a viscosity to enable flow to the ejection point under the pressure supplied by spring 11 and droplet formation. At the ejection point the electrostatic charge causes droplet formation as discussed earlier.

FIG. 2 illustrates another embodiment of the apparatus for generation of discrete droplets from a solid ink. Those parts which are the same as in FIG. 1 have the same reference numerals.

A body 1 which may be of an insulating material is fashioned to a tapered point. Extending from the body is a tube 2 of a thermally and electrically conducting material which is electrically charged by electrical conductor 3 extending from a power source 4. The ejection point 6 is at the tip of the tube 2 and tapers to a point of a selected radius of curvature, in this case a spherical point. The body has a hollow aperture 7 extending through it to the tube 2 and the ejection point 6. The aperture 7 is adapted to receive a stick 9 of a solid ink. A heating coil 10 around the aperture 7 softens and expands the ink 9 extruding said ink through aperture 7 into the tube 2 such that ink of the correct viscosity to allow droplet formation flows to the ejection point 6 under pressure. At the ejection point the electrostatic charge causes droplet formation as discussed earlier. A plug 15 closes off the end of the aperture 7 remote from the tube 2 to enable pressure formed by expansion of the meltable ink on melting to direct ink to the ejection point 6.

FIG. 3 illustrates yet another embodiment of the apparatus for generation of discrete droplets from a solid ink. Those parts which are the same as in FIG. 1 have the same reference numerals.

A body 1 which may be of an insulating material fashioned to a tapered point. Extending from the body is a hollow tube 2 of a thermally and electrically conducting material which is electrically charged by electrical conductor 3 extending from a power source 4. The ejection point 6 is formed at a tip of the tube 2 which tapers to a point on one edge of the tube of a selected radius of curvature, in this case a spherical point. The body has an aperture 7 extending through

it to the tube 2. The aperture 7 is comprised of first portion 8 of a first diameter adapted to receive a stick 9 of a solid ink. A heating coil 10 around the first portion 8 provides heating to soften the stick of ink 9 to such an extent that spring 11 can extrude the ink through the tapered portion 12 of the aperture 7 into a second portion 13 of reduced diameter and into the tube 2. Further heating is provided by an infrared solid state laser diode 16 and an optical fibre 17 directed to the tube 2. This provides heat which further melts the ink until it is at a viscosity to flow to the ejection point and to enable formation of droplets. At the ejection point the electrostatic charge causes droplet formation, as discussed earlier, when the viscosity has been reduced by the heat from the infrared solid state laser diode 16 via the optical fibre 17. This heating may be pulsed to enable selected or pulsed formation and ejection of droplets.

Examples of operation of droplet formation according to this invention are given in the following examples 1 to 6.

In these examples an ink was provided by blending 99g of Syntha Wax (a hydrogenated castor oil) and 1g of Pigment Blue 15 which were placed into a heated attritor milling device and heated to 150C to affect the melting of the thermoplastic materials. After milling for 6 hours, the molten ink was removed from the attritor and allowed to solidify by cooling.

Viscosity of this ink at an operational temperature to allow droplet formation was 10 mPa.s.

<u>Example 1</u>

This ink was placed in the apparatus as described with reference to the embodiments shown in FIG 1. with bond paper placed 20mm from the single point ejection location with a radius of curvature of 25 microns. Excellent results were obtained when the ejection location was at 135 C and + 600 volt pulses were applied at 5000 Hz on top of the threshold potential of +1500 volts. Printed drop size was 10 microns with excellent colour density and integrity.

Example 2

This ink was placed in the apparatus as described in FIG 1. with bond paper placed 20mm from the single point ejection location with a radius of curvature of 25 microns. Excellent results were obtained when the ejection location was at 135 C and +800 volt pulses were applied at 5000 Hz on top of the threshold potential of +2000 volts. Printed drop size was 20 microns with excellent colour density and integrity.

Example 3

This ink was placed in the apparatus as described in FIG 1. with bond paper placed 10mm from the single point ejection location with a radius of curvature of 25 microns. Excellent results were obtained when the ejection location was at 135 C and +600 volt pulses were applied at 5000 Hz on top of the threshold potential of +1500 volts. Printed drop size was 70 microns with excellent colour density and integrity.

Example 4

This ink was placed in the apparatus as described in FIG 1. with bond paper placed 10mm from the single point ejection location with a radius of curvature of 25 microns. Excellent results were obtained when the ejection location was at 135 C and +800 volt pulses were applied at 5000 Hz on top of the threshold potential of +2000 volts. Printed drop size was 150 microns with excellent colour density and integrity.

Example 5

This ink was placed in the apparatus as described in FIG 1. with bond paper placed 5mm from the single point ejection location with a radius of curvature of 25 microns. Excellent results were obtained when the ejection location was at 135 C and +600 volt pulses were applied at 5000 Hz on top of the threshold potential of +1500 volts. Printed drop size was 150 microns with excellent colour density and integrity.

Example 6

This ink was placed in the apparatus as described in FIG 1. with bond paper placed 5mm from the single point ejection location with a radius of curvature of 25 microns. Excellent results were obtained when the ejection location was at 135 C and +800 volt pulses were applied at 5000 Hz on top of the threshold potential of +2000 volts. Printed drop size was 300 microns with excellent colour density and integrity.

The Examples 7 to 13 illustrate droplet formation according to the method and apparatus of this invention with other inks. These inks were manufactured by the method as disclosed in previous examples. All viscosity measurements in these examples were performed on a Haake Rheometer: Rheostress RS100.

Example 7

Paraffin Wax	43g
AC-6	43g
Irgalite Blue LGLD	4g

Viscosity of this ink at operational temperature was 45 mPa.s

The ink was placed in the apparatus as described with reference to the embodiment shown in FIG 1. with bond paper placed 10mm from a single point ejection location with a radius of curvature of 25 microns. Excellent results were obtained when the ejection location was at 135 C and +800 volt pulses were applied at 5000 Hz on top of the threshold potential of +2000 volts. The printed drop had excellent colour density and integrity.

Example 8

Paraffin Wax	80g
Elvax 210	9g
Irgalite Blue LGLD	4g

Viscosity of this ink at operational temperature was 32 mPa.s

The ink was placed in the apparatus as described with reference to the embodiment shown in FIG 1. with bond paper placed 10mm from the single point ejection location with a radius of curvature of 25 microns.

Excellent results were obtained when the ejection location was at 135 C and +800 volt pulses were applied at 5000 Hz on top of the threshold potential of +2000 volts. The printed drop had excellent colour density and integrity.

Example 9

Paraffin Wax	80g
Elvax 210	9g
Energol WM2	20g
Irgalite Blue LGLD	4g

Viscosity of this ink at operational temperatures was 15 mPa.s.

The ink was placed in the apparatus as described with reference to the embodiment shown in FIG. 1 with bond paper placed 10mm from the single point ejection location with a radius of curvature of 25 microns. Excellent results were obtained when the ejection location was at 135C and +800 volt pulses were applied at 5000 Hz on top of the threshold potential of +2000 volts. The printed drop had excellent colour density and integrity.

Example 10

Paraffin Wax	49g
AC6	49g
Irgalite Blue LGLD	1g

Viscosity of this ink at operational temperature was 31 mPa.s.

The ink was placed in the apparatus as described with reference to the embodiment shown in FIG. 1 with bond paper placed 10mm from the single point ejection location with a radius of curvature of 25 microns. Excellent results were obtained when the ejection location was at 135 C and +800 volt pulses were applied at 5000 Hz on top of the threshold potential of +2000 volts. The printed drop had excellent colour density.

Example 11

Paraffin Wax	99g
Microlith Black CT	1g

Viscosity of this ink at operational temperature was 2.5 mPa.s.

The ink was placed in the apparatus as described with reference to the embodiment shown in FIG. 1 with bond paper placed 10mm from the single point ejection location with a radius of curvature of 25 microns. The ejection location was at 135C and +800 volt pulses were applied at 5000 Hz on top of the threshold potential of +2000 volts. The printed drop had poor colour density and integrity.

Example 12

Paraffin Wax	99g
Monolite Yellow GNA	1g

Viscosity of this ink at operational temperature was 13 mPa.s.

The ink was placed in the apparatus as described with reference to the embodiment shown in FIG. 1 with bond paper placed 10mm from the single point ejection location with a radius of curvature of 25 microns. The ejection location was at 135C and +800 volt pulses were applied at 5000 Hz on top of the threshold potential of +2000 volts. The printed drop had poor colour density and integrity.

Example 13

Paraffin Wax	43g
AC6	43g
Irgalite Blue LGLD	1g

Viscosity of this ink at operational temperature was 45 mPa.s.

The ink was placed in the apparatus as described with reference to the embodiment shown in FIG. 3 with bond paper placed 10mm from the single point ejection location with a radius of curvature of 25 microns. Excellent results were obtained when the ejection location was at 135C and the laser was modulated at 5000 Hz. A potential of +2800

volts was applied to the ejection location. The printed drop had an excellent colour density and integrity.

It will be seen that by this invention there is provided a simple method and apparatus by which droplets of a meltable solid, powdered or highly viscous material such as an ink may be produced.

1. An apparatus for generation of droplets of a material from a meltable powdered, solid or highly viscous material comprising means to reduce the viscosity of the powdered, solid or highly viscous material to a viscosity which will enable droplet formation, means to supply the reduced viscosity material to an ejection location, and means to apply an electrical potential to the ejection location to form an electric field at the ejection location whereby to enable formation and ejection of droplets of the material from the ejection location.

2. An apparatus for generation of droplets of a material from a meltable powdered, solid or highly viscous material comprising a particulate solid and a meltable carrier, the apparatus comprising viscosity reduction means to reduce the viscosity of the material to a viscosity which will enable droplet formation, means to supply the reduced viscosity material to an ejection location, and means to apply an electrical potential to the ejection location to form an electrostatic field at the ejection location whereby to enable formation and ejection of droplets of the material from the ejection location by electrostatic repulsion.

3. An apparatus as in Claim 2 wherein the means to reduce the viscosity of the powdered, solid or highly viscous material reduces the viscosity by heating or by pressure.

4. An apparatus as in Claim 2 wherein the means to supply the reduced viscosity material to an ejection location comprises a spring loaded chamber adapted to contain pellets or a stick of the material and wherein the means to reduce the viscosity includes resistance or induction heating means to melt the pellets or stick of the material to the required viscosity.

5. An apparatus as in Claim 4 wherein the means to reduce the viscosity includes a two stage heating means with the first stage adapted to soften the material to such a viscosity that it can be forced to a second stage heater which is adapted to reduce the viscosity of the material to the final required viscosity.

6. An apparatus as in Claim 2 wherein the ejection location includes heating means to maintain the viscosity of the material at a viscosity which will enable droplet formation.

7. An apparatus as in Claim 6 wherein the heating means at the ejection location comprises a solid state infra red laser diode.

8. An apparatus as in Claim 7 wherein the solid state infra red laser diode is adapted to be pulsed to provide intermittent heating of the ejection location.

9. An apparatus as in Claim 2 wherein the ejection location is selected from a needle point having a radius of curvature of from 5 to 50 microns, an elongate edge having a semi cylindrical surface having a radius of curvature of 5 to 50 microns or a matrix of ejection points.

10. An apparatus as in Claim 2 wherein the means to apply an electrical potential to the ejection includes means to pulse the electrical potential so that there is periodic formation and ejection of droplets from the ejection location.

11. An apparatus for the generation of droplets of an ink from a solid meltable ink, the ink being of a type including a pigment and a meltable carrier, the apparatus comprising a body having a chamber therein to receive the solid ink, heating means to melt the ink within the chamber, a capillary tube extending from the chamber to an ejection location to supply melted ink to the ejection location and means to apply an electrical potential to the ejection location to form an electrostatic field at the ejection location whereby to enable formation and ejection of droplets of the ink from the ejection location by electrostatic repulsion.

12. An apparatus for the generation of droplets of an ink from a solid meltable ink as in Claim 11 further including means to pulse the electrical potential to thereby enable periodic formation and ejection of droplets from the ejection location.

13. An apparatus for the generation of droplets of an ink from a solid meltable ink as in Claim 11 further including means to provide

intermittent heating of the ejection location to reduce the viscosity of the ink at the ejection location to thereby enable periodic formation and ejection of droplets from the ejection location.

14. An apparatus for the generation of droplets of an ink from a solid meltable ink as in Claim 13 wherein the means to provide intermittent heating of the ejection location to reduce the viscosity of the ink at the ejection location is a solid state infra red laser diode.

15. An apparatus for generation of droplets of a material from a meltable powdered, solid or highly viscous material comprising a particulate solid comprised of chargeable particles and a meltable carrier, the apparatus comprising viscosity reduction means to reduce the viscosity of the powdered, solid or highly viscous material to a viscosity which will enable droplet formation, means to supply the reduced viscosity material to an ejection location, and means to apply an electrical potential to the ejection location to form an electrostatic field at the ejection location whereby to enable formation and ejection of droplets of the material from the ejection location by electrostatic repulsion.

16. An apparatus for generation of droplets of an ink from a meltable powdered, solid or highly viscous ink comprising a particulate pigment of chargeable particles and a meltable carrier, the apparatus comprising viscosity reduction means to reduce the viscosity of the powdered, solid or highly viscous ink to a viscosity which will enable supply of the reduced viscosity ink to an ejection point, means to supply the reduced viscosity material to the ejection point, means to apply an electrical potential to the ejection point to form an electrostatic field at the ejection point and means to provide point source heating of the ejection point to reduce the viscosity of the ink to a viscosity which will enable droplet formation whereby to enable formation and ejection of droplets of the material from the ejection location by electrostatic repulsion.

17. A method of formation of droplets from a meltable powdered, solid or highly viscous material comprising the steps of reducing the viscosity of the material to a viscosity which enable droplet formation, providing the reduced viscosity material to an

ejection location, applying an electrical potential to the ejection location to form an electric field at the location and thereby causing the reduced viscosity material to form droplets on the ejection location and ejecting such droplets away from the ejection location by electrostatic repulsion.

18. A method as in Claim 17 wherein the viscosity is reduced by heating or by pressure.

19. A method as in Claim 17 wherein the electrical potential forming the electric field is constant and the droplet formation is dependant upon the degree of reduction of viscosity.

20. A method as in Claim 17 wherein the heating to provide reduction in viscosity is pulsed so that there is periodic formation and ejection of droplets from the ejection location.

21. A method as in Claim 17 wherein the reduction of viscosity is constant and the droplet formation is dependant upon the variation of the electrical potential forming the electric field.

22. A method as in Claim 21 wherein the electrical potential forming the field is pulsed so that there is periodic formation and ejection of droplets from the ejection location.

23. A method as in Claim 17 wherein the ejection location is provided by a needle having a radius of curvature at its tip in the range of 5-50 microns.

24. A method as in Claim 17 wherein the ejection location is provided by an elongate sharpened edge providing a number of ejection locations along the elongate edge or by a matrix of ejection locations.

25. A method as in Claim 17 wherein the solid or highly viscous material is an ink comprised of a carrier and a pigment and the carrier is a non-electrically conducting when in the reduced viscosity state and the pigment is comprised of chargeable particles.

26. A method as in Claim 25 wherein the chargeable particles are chargeable to the same polarity as the electrical potential applied to the ejection location.

27. A method as in Claim 25 wherein the ink is comprised of a low melting point wax or resin combined with a pigment and the wax or resin is selected from a low molecular weight polyethylene, hydrogenated castor oil, ester wax, paraffin wax, rosins, and ethylene vinyl acetate copolymers and mixtures thereof and the pigment is selected from organic pigments such as Pigment Blue 15, Pigment Yellow 1 and Pigment Black 7 or inorganic pigments such as silicas, metallics or magnetic iron oxides.

28. A method as in Claim 17 wherein the electrical potential applied to the ejection location is in the range of +500 to +5000 volts.

29. A method of formation of droplets of ink for printing purposes from a meltable powdered, solid or highly viscous ink, the ink comprising a pigment comprising chargeable particles and a non-conducting carrier, the method comprising the steps of reducing the viscosity of the ink by heating means to a viscosity which enable droplet formation, flowing the reduced viscosity ink to an ejection point, applying an electrical potential to the ejection point to form an electrostatic field at the location and thereby causing the reduced viscosity material to form droplets on the ejection point and ejecting such droplets away from the ejection point by electrostatic means.

30. A method of formation of droplets of ink for printing purposes from a meltable powdered, solid or highly viscous ink, the ink comprising a pigment comprising chargeable particles and a non-conducting meltable carrier, the method comprising the steps of reducing the viscosity of the ink by heating means to a viscosity which will enable flow of the melted ink to an ejection point, flowing the reduced viscosity ink to the ejection point, applying an electrical potential to the ejection point to form an electrostatic field at the location, providing point source heating at the ejection point to reduce the viscosity of the ink to a viscosity which will enable droplet formation and thereby causing the reduced viscosity material to form droplets on the ejection point and ejecting such droplets away from the ejection point by electrostatic means.

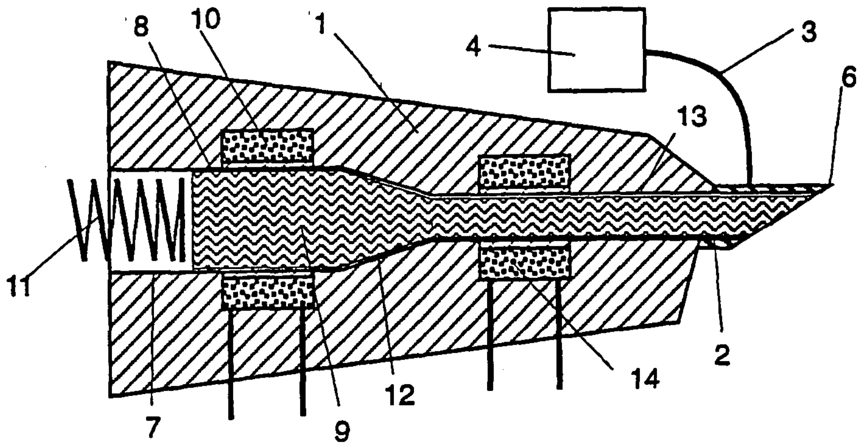

fig 1

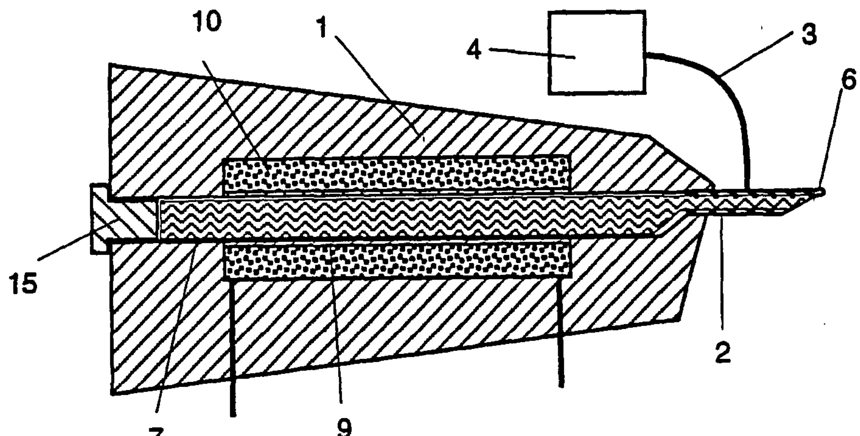

fig 2

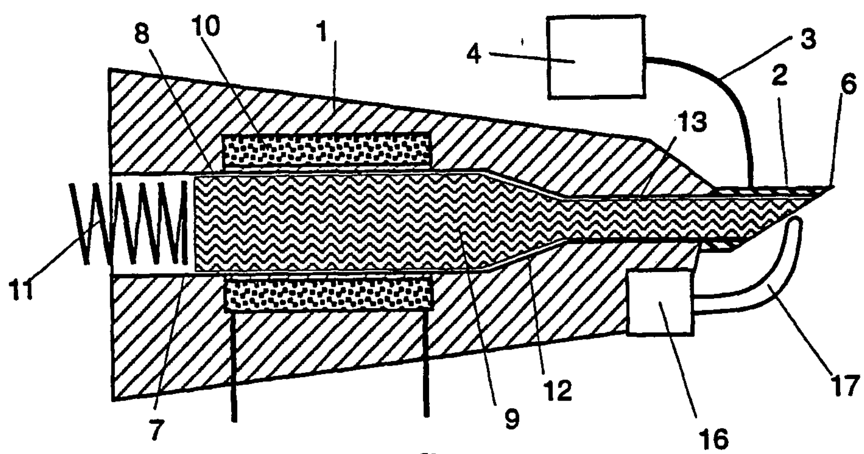

fig 3

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.^{5} B41J 2/06, B05B 1/02, 5/025

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC B05B 1/02, 1/24, B41J 2/02, 2/03, 2/035, 2/04, 2/06, 3/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : IPC as above

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)
DERWENT : VISC: OR ELEC:()FIELD: OR MELT:
JAPIO : VISC: AND ELEC:()FIELD

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
Y	US,A, 4717926 (HOTOMI) 5 January 1988 (05.01.88) col 2 line 24 - col 3 line 29, figs 1(a)-2(b)	1-8,10-22,24-27,29,30
Y	EP,A, 178880(EXXON RESEARCH AND ENGINEERING COMPANY) 23 April 1986 (23.04.86) page 4 line 11 - page 5 line 18, figs 1,2	1-5,10-22,24-27,29,30
Y	EP,A, 181218 (EXXON RESEARCH AND ENGINEERING COMPANY) 14 May 1986 (14.05.86) page 5 lines 1-21, figs 1,2	1-3,10-22,24-27,29,30

(continued)

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 May 1994 (20.05.94)	25 May 1994 (25.05.94)

Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. 06 2853929	E.N. PERRIS Telephone No. (06) 2832167

C(Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
Y	EP,A, 213240 (EXXON RESEARCH AND ENGINEERING COMPANY) 11 March 1987 (11.03.87) col 4 line 10 - col 5 line 35, figs 1-3	1-3,6-8,10-22,24-27, 29,30
Y	US,A, 4490731 (VAUGHT) 25 December 1984 (25.12.84) col 3 lines 3-24, fig 1	1-3,6-8,10-22,24-27, 29.30
P,Y	WO,A, 93/11866 (RESEARCH LABORATORIES OF AUSTRALIA PTY LTD) 24 June 1993 (24.06.93) page 3 line 4 - page 6 line 14	1-30
A	EP,A, 97823 (IBM CORP) 11 January 1984 (11.01.84) Whole document	
A	US,A, 4349829 (BOVIO et al) 14 September 1982 (14.09.82) Whole document	
A	US,A, 4575737 (VERMONT-GAUD et al) 11 March 1986 (11.03.86) Whole document	
P,A	Patent Abstracts of Japan, M-1443, page 46, JP,A, 5-57907 (FUJI XEROX CO LTD) 9 March 1993 (09.03.93) Abstract	

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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US	4575737	CH	649040	EP	106802	WO	8401544

END OF ANNEX